# LITHIC REFITTING AND INTRASITE ARTIFACT TRANSPORT: A VIEW FROM THE MIDDLE PALEOLITHIC

Manuel Vaquero [a, b, *] , Francesca Romagnoli [c], Amèlia Bargalló [d], M. Gema Chacón [a, b, e], Bruno Gómez de Soler [a, b], Andrea Picin, Eudald Carbonell [a, b]

[a] IPHES, Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Zona Educacional 4, Campus Sescelades URV (Edifici W3), 43007 Tarragona, Spain.

[b] Àrea de Prehistòria, Universitat Rovira i Virgili (URV), Avinguda de Catalunya 35, 43002 Tarragona, Spain.

[c] Departamento de Prehistoria y Arqueología, Universidad Autónoma de Madrid, Ciudad Universitaria de Cantoblanco, 28049 Madrid, Spain.

[d] Institute of Archaeology, University College London, Gordon Square 31-34, London WC1HOPY, Great Britain.

[e] UMR7194 – HNHP (CNRS – MNHN –UPVD – Sorbonne Universités), 1 rue René Panhard, 75013 Paris – Musée de l'Homme, 17 Place du Trocadéro, 75016 Paris, France.

[*] Corresponding author; e-mail: manuel.vaquero@urv.cat

## Abstract

The intrasite mobility of lithic artifacts is one of the most relevant issues that can be approached from the spatial study of refitting. In many sites, it has been found that some artifacts were abandoned at considerable distance from the place where they were produced. Once natural causes of post-depositional nature are discarded, the most likely hypothesis to explain these movements is intentional displacement by humans. However, the interpretation of such intentional movements is particularly difficult, since the intrasite mobility of lithic artifacts can be related to at least four different factors: a) refuse disposal strategies; b) functional complementarity between different activity areas; c) social relations between different domestic units; and d) recycling. Each of these factors has different implications concerning questions as important as the spatial organization within the campsites or the contemporaneity between activity areas. To address this issue, it is necessary to have a representative sample of transport episodes and to analyze aspects such as the connection length, the directionality of the movements, the kind of transported artifacts and the activities carried out both in the place of origin and in the place of destination. As an example, in this work we are going to analyze the long distance displacements identified in different Middle Paleolithic layers from the Abric Romaní (Capellades, Spain).

**Keywords**: refitting, intrasite movement, Middle Paleolithic, recycling, Abric Romaní

## 1. Introduction

Refitting is a far-reaching method; whose results can bring useful information on a wide array of archeological topics. Among these, those related to spatial analysis have played a primary role, especially from the moment when researchers became interested in the spatial dimension of archeological sites (Cziesla 1990; Schurmans 2007). From an historical and theoretical point of view, these spatial perspectives were closely linked to the emergence of the ethnographic paradigm in the interpretation of the archeological record and refitting played a role in constructing this ethnographic picture of hunter-gatherer sites. Refitting has been a key argument for identifying and characterizing activity areas. In the case of lithics, it has been essential to establish which technical events were carried out on the spot. In this context, the intrasite movement of lithic artifacts is one of the most relevant issues that have been approached from refitting. It provides high-resolution data concerning practically all the questions discussed in spatial studies, including the different processes, both natural and anthropogenic, involved in the formation of archeological assemblages (Morrow 1996; Petraglia 1992) and post-depositional dynamics (Todd and Stanford 1992; Vallin et al. 2001; Villa 1982). In particular, lithic refitting can bring fundamental insights for interpreting the spatial distribution of artifacts, especially concerning far-reaching questions such as whether different activity areas were complementary or different domestic units were contemporaneous. From this late question, we can get a glimpse of the social composition of hunter-gatherer bands, since connections can be interpreted in terms of the number of domestic units living together or the strength of the social ties linking them.

However, the use of refitting data to approach these issues is becoming particularly difficult because of two main problems. First, the interpretation of the intrasite movements is conditioned by the diversity of processes that can cause the mobility of the artifacts and by the equifinality of some of these causes. Some of these processes can affect equally all the archeological remains, but some of them tend to be more common either on lithic or bone remains. Since this paper is focused on the movement of stone artifacts, we will pay spatial attention to the processes acting on lithics. The first distinction to be taken into account has to do with the natural or anthropogenic character of the movements. Natural processes include the following:

- Geological processes, such as water currents, mud flows or slope displacements due to gravity. In general, the incidence of these natural factors depends on the size and/or weight of the items and they tend to produce a size sorting of remains (Bertran et al. 2012; Rick 1976; Schick 1987). The movements by water affect especially the small remains, while the largest and heaviest artifacts move more by gravity. Eolian processes can also remove the smallest artifacts from a lithic assemblage (Rick 2002).

- Non-human biological agents, such as carnivores. Although bone remains are the most affected when carnivores scavenge assemblages previously generated by humans (Binford et al. 1988), the movement of lithics by these agents has been also recorded (Camarós et al. 2013). In the experimental series reported by Camarós et al., all the artifacts located around a hearth were moved by carnivores. In particular, bears moved a quartzite hammerstone more than nine meters and a flint flake more than five meters. The borrowing behavior of some animals can also alter the original location of archeological items, although this is especially significant in vertical displacements and its role in long-distance horizontal movements can be dismissed (Balek 2002).

In turn, anthropogenic movements can also be of very different nature. At a first glance, these displacements may be distinguished according to their intentionality. On the one hand, unintentional movements are related to the mobility of individuals (foot traffic, trampling). The unintentional scuffage by foot traffic (Stevenson 1991; Theunissen et al. 1998) also produce a size sorting of artifacts, since large items, which take longer to be buried, are more likely to be moved away from the activity areas. These movements would be more common in the more frequented zones and especially along the paths habitually used by the site's inhabitants. According to Theunissen et al. (1998), cave and rockshelter ceiling-height influences the location of these traffic zones by conditioning where humans can comfortably walk. Moreover, other structural features must be also considered, like the location of the cave's entrance or the presence of large fallen blocks that can restrict or channel human traffic. Anyway, the longer the knapping scatters remain exposed on the surface, the more important these dispersions will be. The differential scattering of knapping events can be therefore used to propose hypotheses about their relative chronology. On the other hand, intentional displacements are generally framed in two different contexts:

- Cleaning and refuse disposal, either individually (tossing) or in bulk (dumping). As pointed out in ethnoarcheological contexts (Binford 1978; O'Connell 1987; O'Connell et al. 1991), large artifacts are also the more likely to be tossed aside from the hearth-related activity areas. The accumulation of large items in the activity areas can be annoying or even dangerous, which is why they tend to be displaced during or at the end of the activity. This behavior is the basis of the distinction between drop and toss zones in the Binford's classic model for the formation of hearth-related assemblages. Size sorting may be also the result of cleaning-up activities, in which the primary refuse accumulated in the activity locus is removed to a dumping area. Small debris tends to be buried quickly or go unnoticed and therefore remain in the activity area. Large items, which are visible for a longer time, are more likely to be removed to refuse disposal zones. Cleaning-up and dumping in secondary deposits depends on occupation length and would be unlikely in short-term camps (O'Connell 1987).

- Actual or anticipated use of artifacts. This is the most interesting context when analyzing the relations between activity areas. Tools can be moved from the knapping area to the locus where they will be used, when these activities are spatially segregated. However, artifacts can be also moved between areas that are similar from the functional point of view, for instance, hearth-related domestic areas. These inter-household movements may be the expression of social or kinship relations. In the case of bone refitting, this is the most usual argument for identifying food sharing between contemporaneous domestic units (Enloe 2003; Enloe and David 1992). Nevertheless, this evidence is less straightforward when lithic refits are concerned, although some kind of 'artifact sharing' can be also envisaged. Unfortunately, we lack good ethnoarcheological references about the sharing of lithic resources in hunter-gatherer bands. Although this topic has been less discussed in archeological and ethnographic literature, some movements may be related to learning. For example, cores discarded by expert knappers may be moved and reduced again by apprentices, generating spatially segregated lithic scatters.

However, the interpretation of these anthropogenic movements is conditioned by a second set of problems related to the temporal dimension of archeological assemblages, which are normally defined according to stratigraphic criteria. These assemblages result from the accumulation of activity events that, continuously or discontinuously, take place in the same space over a more or less prolonged period of time. The recognition that the archeological assemblages are palimpsests derives a series of issues that have been widely discussed (Bailey 2007; Bailey and Galadinou 2009; Binford 1981; Clark 2017; Lyman 2003; Malinsky-Buller et al. 2011; Schiffer 1985; Sullivan III 2008). These issues are particularly acute when trying to interpret spatial patterns in behavioral terms. The temporal dimension is the main challenge in studies of spatial distribution, in such a way that spatial studies should not be considered exclusively spatial, but spatio-temporal. Accordingly, we think that time issues are also one of the main challenges in refitting studies. The intentional displacement of artifacts has very different implications depending on the temporal difference between the activities carried out in the areas of origin and destination of the displacement. The main issue at stake is to what extent we can expect to establish an occupational contemporaneity, which refers to the events which occurred during a single occupation (Conard and Adler 1997). This is a temporal scale defined by the period during which a space is continuously inhabited by a human group. However, the occupation may be considered an ethnographic concept, whose translation to archeological terms is always problematic. Concerning this question, we can envisage two different scenarios in order to interpret artifact movements between activity areas. These scenarios have very different implications from the viewpoint of the behavioral and social interpretation of the lithic assemblage:

- The connected areas are contemporary, so the displacement can be informing us on aspects such as the complementarity between areas differentiated from the functional point of view or the coexistence of different domestic units in the same camp.

- The connected areas are diachronic, so the movement is informing us about the recycling of lithic resources throughout the formation of the archeological assemblage.

The contemporaneity vs. recycling dilemma is currently the key issue when approaching the intrasite movement of lithic artifacts. Recent research on recycling suggests that reuse of discarded lithics in Paleolithic contexts was probably more common than previously thought (e.g. Barkai et al 2015). Occupation places were surely landmarks well-known by the hunter-gatherers living around them, who were fully aware of the presence of lithic resources on the surface of those sites. Recycling was therefore a provisioning option and it could be an additional motif for the repeated visits to some locations. Moreover, it is a low-cost way to solve immediate needs. Consequently, recycling should be systematically envisaged when trying to explain artifact movements. At first glance, it seems that this problem would be particularly important in cave and rock-shelter sites, where the reoccupation of the same space would be more common than in open-air sites. However, some of the best examples of intrasite artifact transport have been found in open-air locations, in which the recycling hypothesis has been rarely discussed (among the exceptions, see Roebroeks 1988).

We should recognize that we are facing a kind of circular problem, since we need to know the temporal relationship between areas to interpret refitting, but at the same time we try to use refitting to establish the temporal relationship between areas. In this sense, the direction of the movements could bring some clues on these temporal issues. Unidirectional patterns (only from A to B) are not a good evidence to argue that two areas were contemporaneous. Bidirectional movements (from A to B, but also from B to A) can be used to support the contemporaneity hypothesis. Obviously, this does not mean that unidirectional connections, or even the absence of connections, prove that two activity areas are not contemporaneous. This seems something particularly difficult to prove. A scenario of contemporaneous units without transport of artifacts between them can be perfectly envisaged. Anyway, we are assuming that the simplest scenario – that is, the activity areas are not contemporaneous – should be considered as the default hypothesis and the more complex scenario – the activity areas are contemporaneous – is therefore what should be argued with empirical data.

In order to use this evidence, it is important not to focus on single movements, but to evaluate the robustness of the patterns. A robust bidirectional pattern would be more likely in the context of contemporaneous units. Moreover, this question cannot be solved exclusively through refitting. All the contextual evidence, including the archeological content of the connected areas, can bring fundamental data. The patterns inferred from bone refitting are particularly important. In fact, it has been suggested that the movement of bones is the best evidence indicating that two areas were contemporaneous (O'Brien 2015; Rapson and Todd 1992). The characteristics of the moved artifacts can also provide some clues. It has been suggested in some contexts that the movement of target products (e.g. Levallois products, blades, bladelets) would be more consistent with synchronic relations, since these artifacts cannot be considered as waste. The movement of blades and bladelets from their knapping spots in the habitation unit Q31 of Étiolles would be a good example of this (Olive and Morgenstern 2004). However, it is not always evident what kind of artifacts should be considered as target products, since this depends sometimes on contentious technological assumptions about the distinction between predetermined and predetermining artifacts.

The aim of this paper is to approach these questions using the refitting data from the Abric Romaní, a Middle Paleolithic site from northeastern Iberia. Spatial issues have been at the center of the Abric Romaní excavation since the beginning of the current project. The field strategy, including the excavation of large surfaces and the three-dimensional recording of archeological remains, has been from the outset conditioned by these spatial considerations. Although our approach to the spatial record of the Abric Romaní has been changing over time, from a paleoethnographic and synchronic vision to a more complex and realistic one, refitting – both of bone and lithic remains – has been always an integral part of it. The amount of lithic refits found at the different archeological units allows us a quantitative approach to connection data. We think that this is particularly important, since refits are too often presented in a qualitative way. Publication of numerical data is fundamental for inter-site comparisons, which is a promising avenue for future research on refitting. Specifically, the questions addressed in this paper will be the following:

- What role do artifact movements play in the spatial distribution of artifacts?

- Are there inter-assemblage differences in the frequency of movements or the type of moved artefacts? If so, what are the causes of these differences?

- Are there differences in the degree of movement depending on the size or technological category of the artifacts?

- Can be discerned the different processes causing artifact movements? In particular, what role could natural processes play in the movement of artifacts?

- Do refit connections contribute relevant information about the temporal relationship between activity areas?

## 2. Material and methods

We will analyze these issues from the lithic refits documented at different levels of the Abric Romani sequence. The Abric Romaní site is located in the town of Capellades, in the northeast of the Iberian Peninsula (Fig. 1). Current excavations have allowed a ~ 50 m thick sedimentary deposit, dated by U-Series and $^{14}C$ AMS as between 40 and 110 kyr BP (Sharp et al. 2016; Vaquero et al. 2013), to be discovered. The stratigraphic sequence has been presented elsewhere (Vallverdú-Poch et al. 2012; Vaquero et al. 2013) and will not be described in detail here. With the exception of the uppermost archeological unit (level A), corresponding to the Early Upper Paleolithic, all the levels so far excavated (B to Q) are Middle Paleolithic. The sedimentary dynamics, mostly based on the formation of tufas and characterized by a rapid sedimentary rate, have led to a well-preserved archeological record and enabled a high-resolution approach to behavioral patterns. The Abric Romaní excavation was organized from the outset with the objective of analyzing the spatial organization strategies of Middle Paleolithic societies. For this purpose, a large area (200-300 m2) has been excavated and the spatial location of the archeological remains larger than 1 cm has been carefully recorded. The excavation method is based on a grid of 1x1 m squares and all the excavated sediment is wet sieved through a 1 mm mesh. The sedimentary conditions have favored the preservation of archeological items uncommon in other sites, like the wooden artifacts, and a good record of combustion features.

A large number of hearths have been found at all the archeological units discussed in this paper. Combustion structures played a primary role in the spatial patterns and most lithic and bone remains are clustered in hearth-related areas, which suggest that the Abric Romaní was basically a residential space. This spatial layout is particularly evident in some units (levels H, I, K, L, and N) that show a discrete distribution, in which different clusters can be easily distinguished. In other units (levels J, M and O), such discrete pattern is less evident due to the overlapping of hearth-related activity areas. The hearth-related assemblages are the best represented spatial unit in all the archeological units of Abric Romaní. They are a structural feature in cultural formation processes and the best candidate to be considered as an "ethnographic reality". Other spatial units, like specialized areas or dumping areas, are uncommon and always affected by the uncertainties arising from the temporal nature of the archeological assemblages.

The faunal assemblages are characterized by the dominance of reed deer and horse remains, although other species (*Bos* sp., rhinoceros, and goat) have also been identified. Chert is the dominant raw material at all the archeological units, although some of them show also a significant exploitation of limestone and quartz. Chert nodules comes from different sources, mainly located in a 25 km radius around the site, and are characterized by a marked macroscopic variability in color and texture, which is very helpful in the first stages of refitting. Most units exhibit a particularly expedient technical behavior, in which discoid and other low-cost knapping strategies are clearly dominant. The main exceptions to this pattern can be found in levels O and P, which are characterized respectively by the use of the Levallois method and the production of blades and bladelets. Denticulates and notches are the most common retouched artifacts.

Due to the high sedimentary rate, the palimpsests are less well-developed than in other sites because the overlapping of activity events is more limited. However, archeostratigraphical analysis has allowed us to distinguish different stratigraphic units in some layers (J, M, O and P) (Fig. 2). In addition, we have independent lines of evidence indicating that the stratigraphic units were made up of the succession of different occupation events. Microstratigraphical studies suggest that some combustion areas were produced by the overlapping of different elemental hearths (Vallverdú i Poch

2018). Anyway, these sedimentary dynamics make refitting more feasible. Refiting studies have been carried out systematically from level H downwards (Bargalló et al. 2016; Vallverdú et al. 2005; Vaquero, 1999, 2008, 2011; Vaquero et al. 2001, 2007, 2012a, 2012b, 2015). This has allowed to accumulate an important number of refits that make possible a quantitative approach. Bone refits are also available for some levels (Gabucio et al. 2018; Modolo and Rosell 2017; Rosell et al. 2012a and b) and a comparison between lithic and bone refitting has been recently published (Vaquero et al., 2017). The archeological units included in this study are levels H to P, dating between 45 and 55 ka BP. While levels H to J were still affected by the pits and trenches of the ancient excavations, levels K to P have been excavated on a continuous surface. Data on levels O and P are preliminary, since the refitting programs of these levels are still ongoing.

In order to focus on movement patterns, we have selected refits with connection lines longer than 5 m. This threshold has been defined taking into account the dispersion radii documented in different knapping experiments, which are consistent with the dispersion radii documented at the different levels of the Abric Romani. Experimental knapping scatters are normally less than 100 cm in diameter, rarely exceeding 200 cm (Barton and Bergman 1982; Böeda and Pelegrin 1985; Newcomer and Sieveking 1980; Schick 1986). However, knapping position has an important effect on debris dispersal. An upright position tends to produce more dispersed scatters, with individual flakes traveling up to four meters (Kvamme 1997; Newcomer and Sieveking 1980). In addition, this distance is above the limit of defined toss zones in hearth-related activity areas, although this does not rule out that some displacements exceeding 5 m are related to waste disposal activities. As a starting assumption, we will consider that any connection greater than 5 m probably involves a displacement, regardless of the causes of such displacement. This does not mean, obviously, that there can be no displacements at shorter distances. The connection lines have been defined according to the temporal order of removals (Cziesla 1990). For each connection line longer than 5 m, we have considered the following variables:

- Type of refit: breakage, production sequence or retouch.

- Connection line length.

- Connection line orientation.

- Functional characterization of the connected areas. In the case of Abric Romaní we have basically differentiated three types of areas:
  - Hearth-related areas associated with households. These areas are clearly dominant in the Abric Romaní and concentrate most of the activity events.
  - Areas with low density of lithics but abundance of bone remains.
  - Marginal areas with low density of archeological remains.

- Direction of the movement, in the cases in which it is possible to identify it. This depends on the ability to identify the knapping spots and the possibility of establishing the point of origin and destination of the movement, which in turn depends on the number of refitted elements and their scattering degree. As the number of refitted artifacts decreases or the scattering degree increases, identifying the direction of the movement becomes more difficult. This is no possible when the refitting set is made up of only two artifacts.

- Size and technological characterization of the moved artifacts.

- Modification of the artifacts after the movement.

Refitting maps of the long-distance connections have been drawn for all the layers, although only the most significant will be commented in this paper. It is important to highlight that we do not pretend to find a general explanation for the long distance connections. Different movements can be due to different causes, since different factors can act on the same assemblage, either synchronously or diachronically. In addition, an artifact can be affected through time by different mobilizing agents and, therefore, the final connection length may be the result of successive transport events. We recognize that the history of each episode of movement should be discussed in detail on a case-by-case basis. Our objective is to provide an overview of long-distance connections and focus on what conclusions can be drawn from this general picture.

## 3. Results

The search for lithic refits has been done in a systematic way in all the Romaní levels. The time and people invested in refitting has not been the same for all the levels, but they have not been quantified in a systematic way. Therefore, the consequences of these differences on the results of the refitting programs cannot be assessed. We do not know if this unequal 'refitting effort' may explain the differences in the refitting rate, which ranges from 22.9 of level H to 5.9 of level K (Table 1). A priori, there are certain aspects of the archeological record of Abric Romaní that make this site a favorable place for refitting. First, the rate and type of sedimentation determine a high resolution of the archeological record and a good vertical separation of the stratigraphic units (Fig 2), which, in comparison with other cave and rock-shelter sites, limits the overlapping of activity events. Secondly, there are data, as we will see below, that indicate, in general terms, a good preservation of the archeological record. However, some characteristics of the lithic assemblages tend to decrease the refitting rate. First, most reduction sequences are highly fragmented and many artifacts were introduced into the site as isolated items. Second, a good part of the reduction sequences were aimed at the production of small flakes, which are more difficult to refit. Moreover, some levels are characterized by a significant amount of patinated artifacts, for which the first stage of refitting – the segregation of lithics according to their macroscopic features – tend to be more complicated. Burnt artifacts are also more difficult to refit, but their percentages are relatively low in all layers, in spite of the large number of hearths.

Table 1.

| *Level* | *Artifacts* | *Refitted artifacts* | *Connection lines* | *Refitting rate* | *Connections > 5m* | *Rate of > 5m connections* | *Mean distance* |
|---|---|---|---|---|---|---|---|
| H | 261 | 60 | 30 | 22.9 | 1 | 3.3 | 81.7 |
| I | 555 | 55 | 31 | 9.9 | 1 | 3.2 | 119.5 |
| J | 6916 | 719 | 461 | 10.4 | 52 | 11.2 | 215.1 |
| K | 1794 | 106 | 63 | 5.9 | 2 | 3.1 | 107.6 |
| L | 1091 | 164 | 118 | 15.03 | 13 | 11.01 | 148.2 |
| M | 4839 | 933 | 638 | 19.2 | 59 | 7.8 | 181.8 |
| N | 542 | 49 | 32 | 9.4 | 1 | 3.1 | 97.1 |
| O | 4855 | 593 | 360 | 12.2 | 28 | 7.7 | 190.8 |
| P | 2521 | 529 | 350 | 20.9 | 17 | 4.8 | 126.1 |

The majority of refits correspond to chert artifacts, as expected given that it is the dominant raw material at all layers. However, refits on quartz and limestone are also common in those units in which these materials have a significant presence. In some units, the refitting rate of limestone is higher than that of flint, like in sublevel Ja (17.6 and 9.4 respectively). All the chert and quartz refitted artifacts are knapping products, while among the limestone refitted items, in addition to knapping products, are also many fragments of cobbles used as percussors. The average connection length ranges from 81.7 cm of level H and 215.1 mm of level J and shows a clear correlation ($R^2$=0.859) with the amount of remains recovered in each level (Fig. 3A). If we take into account that the number of remains is the consequence of the number of activity events, this suggests that the mobility of the artifacts is more related to the intensity or the degree of occupational redundancy than to the natural processes involved in deposit formation, since these are similar at all the archeological units.

Short distance connections are always dominant and connections of less than 2 m represent more than 65% at all levels. However, connections over 5 m have also been documented at all the archeological units, although with different percentages. There is no correlation between the refitting rate and the frequency of long-distance connections. In some units they are very infrequent, with only one (H, I and N levels) or two (level K) connections longer than 5 m. However, in other levels these connections exceed 10% (levels J and L), giving the image of a highly connected space. The percentage of long-distance connection is moderately correlated ($R^2$=0.448) with the number of artifacts (Fig. 3B). However, such moderate value is conditioned by the data from level L, which shows a high percentage of long-distance refits considering the quantity of remains found in this layer. If level L is removed from the analysis, correlation between number of artifacts and percentage of long-distance connections is much stronger ($R^2$=0.951) (Fig. 3C). All the main raw materials are involved in long-distance refits, with a dominance of chert (75%), followed by limestone (19.1%) and quartz (4.6%). Concerning the type of refit, 76.3% of the connections longer than 5 m correspond to reduction sequences and 23.7% to break refits. This proportion between reduction sequence and breakage is similar to that observed for the whole of the refitted assemblages. No long-distance retouch refits have been found, although this is consistent with the virtual absence of this type of refit in the Abric Romaní.

Most connections are made between hearth-related activity areas (66%), followed by connections between hearth-related areas and marginal areas of low density

(28.9%). Connections between hearth-related areas and areas of accumulation of faunal remains are very scarce (n = 3). In virtually all cases, one of the connected areas is a hearth-related area. The only exception is a refit from sublevel Ja that connects two marginal areas with low artifact density. In more than half of the cases (57.2%) it has been possible to identify the direction of the movement and, therefore, the “moved” artifacts. This has been achieved at all the units, except levels H and I. If we consider the characterization of the output and input areas, most movements occur between hearth-related areas. In the vast majority of cases (94%) the place of origin is a hearth-related area. The destination area shows greater variability, with a hearth-related area in 69% of cases and a marginal area of low density in 27.5%. With respect to the whole of long-distance connections, there is an increase of reduction sequence refits (86.2%), while breakage refits are less common (13.8%).

Table 2.

| *Level* | *Technical category* | | | | | *Size* | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | *Core* | *Flake* | *Flake fragment* | *Retouched artifact* | *Fragment* | *Very small* | *Small* | *Medium* | *Large* | *Very large* |
| J | 7 | 6 | 8 | 1 | 5 | 8 | 6 | 1 | 1 | 7 |
| K | | 2 | | | | | 1 | | 1 | |
| L | 2 | 5 | | | | 1 | 2 | 1 | 1 | 1 |
| M | 7 | 16 | 5 | 1 | 1 | 4 | 8 | 4 | 6 | 8 |
| N | | | 1 | | | 1 | | | | |
| O | 1 | 1 | 4 | | 2 | 2 | 2 | 1 | 1 | 2 |
| P | 5 | 6 | 1 | | | 1 | 2 | 1 | 2 | 1 |
| Total | 22 | 36 | 19 | 2 | 8 | 17 | 21 | 8 | 12 | 19 |

Most of the moved artifacts were flakes and flake fragments (62.3%), followed by cores (25.8%) and artifacts – such as cobble fragments (9.4%) – that are not the product of knapping activities (Table 2). The cores have a much higher percentage of moved artifacts than they do in both the material as a whole (1-2%) and in the total number of refitted artifacts (5%), suggesting that they were more likely to be moved than flakes and retouched artifacts. The low intrasite mobility of retouched artifacts (n = 2) should be highlighthed. This is largely due to the fact that most were not manufactured in the site, but were introduced as isolated artifacts. Of the 22 occasions in which the moved artifact was a core, in 10 knapping continued at the place of destination, generating two spatially separated and consecutive knapping areas. From the volumetric point of view, all size categories are represented in the assemblage of mobilized elements. However, higher percentages of large and very large objects is observed (15% and 24% respectively), as compared to the size distribution documented both in the lithic material as a whole (4% and 5%) and in the assemblage of refitted artifacts (4.5% and 6%). This indicates that the overrepresentation of large sizes among displaced objects is not because refitting is easier as artifact size increases. Large and very objects are more likely to be moved.

## 4. Discussion

The refitting evidence from the Abric Romaní indicates that the intrasite movement of lithic artifacts played a significant role in spatial patterns, at least in some archeological units. The mean distance of refits and the frequency of long-distance connections tend to be positively correlated with the amount of artifacts. They are more common in the levels yielding more artifacts and, therefore, including a higher number of activity events. On the contrary, they are less likely as the number of knapping events decreases. This suggests that the agents behind artifact movement need a certain temporal depth to start acting. In fact, this falls within the expected outcomes, since most of the mobilizing processes tend to accentuate as a function of time, regardless of whether we are talking of occupation length or unit formation length. The post-depositional dynamics, both natural and anthropogenic, would be emphasized as formation length increases. Likewise, the likelihood of movements linked to recycling increases as the amount of discarded artifacts is growing. Moreover, an event that requires the transport of artifacts between activity areas will also be more likely to occur. As we have seen previously, level L is the main exception to this trend. This unit exhibits one of the highest rates of long-distance connections, but the lithic assemblage is made up of only 1091 artifacts, far fewer that those found at levels J, K, M, O and P. As we will see later, most of the long-distance movements from level L correspond to artifacts transported to a specific area of the rock-shelter, which suggest that they were probably made in the framework of a single occupation event.

There is contextual evidence that the Abric Romani archeological record is well preserved and that the post-depositional dynamics had little impact on the mobility of the remains. Hearths are well preserved, as well as knapping areas, which usually show a high degree of spatial clustering of the artifacts from the same knapping sequence. In many cases, only the artifacts involved in long-distance connections are separated from much clustered knapping accumulations, which indicate that these movements cannot be the result of a general scattering of the knapping products (some examples from level M are discussed in Vaquero et al., 2015). The clear dominance of short-distance refits at all the archeological units also suggests the good preservation of lithic scatters.

On the other hand, the small remains are clearly dominant, which is at odds with certain post-depositional processes that produce a size sorting of the artifacts. This is especially important if we consider that the dominant sedimentary dynamics are related to the formation of travertines, and therefore we must consider the potential effects of water currents on the mobility of the remains. Bones rounded and polished by water has been documented in some archeological units (Cáceres et al. 2012; Chacón et al 2014; Gabucio et al. 2018; Modolo and Rosell 2016), although there are important differences as far as the percentage of affected remains is concerned. The proportion of bones showing surface abrasion tends to be uncommon in some units (for example, levels I, J and M), with percentages of around 2-5%, but it is much higher in others, like units Oa (42%) and K (34.6%). In most cases, these alterations appear in their initial stages. In addition, the absence of size sorting among the abraded bones suggests that strong currents can be ruled out (Cáceres et al. 2012). As for biological agents, the activity of carnivores is very low throughout the sequence, at least if we take into account the low proportion of carnivore remains and carnivore marks on bone remains (Cáceres et al. 2012; Gabucio et al. 2018; Modolo and Rosell 2016; Rosell et al. 2012b). These contextual data suggest that natural processes did not played a significant role in the mobility of the remains, although each displacement must be analyzed on a case-by-case basis and the role of these processes in some specific movements can not be ruled out.

Concerning this issue, it is important to analyze the potential role of the slope in emphasizing some post-depositional movements. As can be seen in Figure 2, the upper levels show a slight slope in the longitudinal direction, but this slope is progressively reduced, so that the basal levels are almost flat. In a transverse sense (from the wall to the outside of the rock-shelter), a slight slope is seen outwards in some units (I, M, P), while others are practically flat (H, J, N, O). In any case, it does not seem that the slopes are strong enough to cause movements by gravity. Moreover, there is no relationship between the inclination of the levels and the degree of dispersion of the remains. Some of the levels that show more marked slopes (H, I, K) are among those that show a lower degree of artifact movement, judging by the average length of the connection lines and the frequency of long distance movements. Moreover, counter-slope movements are well attested at the units showing the highest percentage of long distance refits (levels J, L and M).

However, there are some mobility patterns suggesting that the incidence of these natural processes should be evaluated in some cases. In general, long distance movements do not show a preferential orientation according to the inclination of the surface. However, one exception can be found in level Ja, where the direction of the long-distance movements in the eastern part of the site shows a preferential NE-SW orientation, following the slope (Fig. 4). Specifically, up to 6 artifacts from different areas of the site went to the southeast end of the rock-shelter, a marginal area characterized by a low density of remains and a scarce presence of combustion structures. Nevertheless, this zone does not present any volumetric selection pattern consistent with natural mobility processes and the moved elements do not show size sorting (3 very small, 1 small and 2 very large artifacts). It is also necessary to evaluate the possible impact of the topography of level Ja. An outer line of large blocks would condition the movements of individuals, probably accentuating the displacements in the sense of the slope, regardless of the intentional or unintentional character of the movements. Some knapping scatters identified in this area also show a NE-SW dispersion pattern (Vaquero et al., 2012b). As we will comment later, there are some counter-slope movements that exhibit this same NE-SW orientation.

All sizes and technical categories are represented among the moved artifacts. Nevertheless, there is a preferential displacement of large artifacts and, especially, cores. This is another argument supporting the primary role of anthropogenic factors, whether intentional or not, in the movement of lithics. Moreover, a parallelism can be established between intrasite and intersite movements. The lithics produced outside and introduced into the site as single artifacts tend to be also large (Vaquero et al. 2012a and 2012b). In level J, this transported toolkit showed a preferential selection of flakes with asymmetrical profile, opposing a back to a cutting edge (*débordant* and naturally backed flakes). As we will see below, some of the intrasite movement events were also characterized by the selection of this kind of artifacts. The inter-site transport of cores was also common, as indicated by the spatial fragmentation of many reduction sequences that were only partially represented in the Abric Romaní.

The greater mobility of very large artifacts forces us to evaluate the role that waste disposal strategies may have played in the pattern of long-distance connections. The absence of movements in bulk allows us to discard strategies of systematic cleaning of the activity areas. However, the individual displacement of large artifacts would be consistent with the behavior associated with the formation of toss zones. In this sense, we must consider that the displacement distance exceeds in general the one described in the formation models of toss areas, at least if we take into account the classic model described by Binford in the Mask site. According to Binford (1978), the mean distance from the kneecap of a seated man for the tossed items ranges between 1.14 and 2.54 m. These movements are below the 5 m threshold that we have used to define long distance displacements. In fact, these toss areas would be inside the scattering radius inferred from knapping experiments. Moreover, it would not be a systematic behavior, since many large elements remained in the drop zones.

From the point of view of the possible relationships between activity areas arising from long distance connections, three different scenarios are observed:

- Poor connectivity at levels H, I, K and N. These units are characterized by a clearly discrete distribution pattern with well-defined hearth-related clusters separated by relatively empty areas. At these levels only one/two long distance connections have been found. Only at level N this connection is made between hearth-related areas. In levels H, I and K these refits connect inner hearth-related areas with outer areas in which bone fragments are common but lithics exhibit comparatively low densities. Only in level K, we have been able to identify the direction of the movement, from inside out. Two flakes produced in a hearth-related area close to the wall were moved to the exterior part of the rockshelter (Fig. 5), in which lithics are scarce but bone remains are relatively abundant. At one of these units (level I), bones exhibit longer connections than lithics (Modolo and Rosell 2016). However, the interpretation of these faunal refits in terms of food sharing is not straightforward, since they mainly correspond to the movement of teeth.

- Frequent long distance connections and clear unidirectional pattern. This scenario has been particularly documented at levels L and M, but also unit Ja exhibits a dominant unidirectional trend. The patterns from levels L and M will be discussed in detail below. The refitting from level J (units Ja and Jb) has been extensively described in Vaquero et al. (2012b).

- Frequent long-distance connections and more complex situations in which bidirectional movements cannot be ruled out, although a unidirectional trend seems to be dominant. This pattern seems to be documented in levels O and P, although the refitting data from these units are still preliminary and we will have to confirm in the future the actual prevalence of such bidirectional movements. We will not comment in detail the refitting pattern from level O, but the main feature is the connection between activity areas located at both ends of the rockshelter, including some connection-lines longer than 15 m. However, to establish the pattern of directionality we will have to wait to complete the refitting program. The lithic movements from level P will be discussed below.

Level L is particularly interesting because it shows a very well defined spatial pattern, characterized by a series of lithic accumulations in hearth-related areas. This allows us to observe a discrete distribution of remains and a movement pattern that is not blurred by the overlap of activity areas. Although the spatial redundancy seems lower than in other levels, it shows frequent long distance movements connecting the different accumulations. These movements show a clearly unidirectional pattern, in which most movements (6 of 7) are directed towards the same accumulation located at the rear of the rock-shelter (Fig. 6). This pattern was interpreted as the result of a succession of occupation events, within the framework of which there would be a recycling of artifacts abandoned in the older episodes (Vaquero 2008). In this context, these movements were used to propose a relative chronology of the activity areas in the formation sequence of level L.

Of the six elements displaced to the central accumulation, four are flakes, two of them *débordant* flakes (Fig. 7). These flakes have a similar size, which points to the same selection criteria. The other two items transported were cores, of which one experienced a last episode of post-transport reduction, while the second was not subject to any modification. We think that these convergent movements are especially important, because they are difficult to explain by natural dynamics or discard strategies, especially if we take into account that all of them exhibit counter-slope directions. This pattern suggests the possibility of identifying provisioning episodes based on intrasite transport, in which elements of similar characteristics were selected in different places of the rock-shelter to be transported to the same area. The occurrence of such provisioning event in level L would explain the differences between this unit and other layers showing similar number of artifacts and spatial patterns.

A similar but more complex pattern has been identified at level M, which is characterized by a greater number of episodes of activity and, therefore, a less defined spatial distribution, although a discrete pattern is still observed. Six main clusters of lithic and bone remains have been identified (Vaquero et al. 2015, 2017) (Fig. 8). In this case, the origin of the long-distance movements corresponds to the accumulations located at the rear of the rock-shelter, while the movements are directed towards the periphery (Fig. 9). The area close to the wall (clusters M2 and M3 in Figure 8) is the main knapping spot in this layer and exhibits the highest density of lithic remains. In particular, several entire reduction sequences, characterized by the introduction of raw nodules and the production of huge quantities of lithics, were carried out in this place. This refitting pattern is entirely different from that exhibited by bone remains, among which long-distance connections are practically absent (Vaquero et al. 2017). This suggests that lithics and bones were not subjected to the same mobilizing processes. Like in level L, what may be considered as transport events – movements from different areas and different reduction sequences converging in the same place – have been identified. We will focus on three of these possible events:

- Accumulation M1 (area A in Figure 9). This is one of the main clusters of remains identified in the spatial analysis and corresponding to the area defined by squares Q-T/41-44. It is one of the areas that receive a greater number of long-distance movements. At least seven flake and flake fragments were moved to this area from different accumulations (Fig. 10). Moreover, refitting indicates that core reduction activities were not common, as only one RMU is focused on this area. It is particularly significant that there are four artifacts with asymmetric profile among the moved items (three *débordant* and one naturally backed flake).

- Square N54 (B in Figure 9). Three artifacts were moved from other areas of the site: two flakes and one core (Fig. 11). The points of origin of these movements are in accumulations M2 (2) and M4 (1). There is a small cluster of artifacts centered in this square, but refits indicate that knapping activities were not common. The two flakes are similar in size and characterized by an asymmetrical profile. The core was not reduced after the movement.

- Squares K52-53 and L52-53 (C in Figure 9). This area is characterized by a very low density of lithic remains and no knapping activities have been so far identified. Five artifacts were displaced from other areas of the rockshelter (Fig. 12). Three of them were cores previously exploited in other accumulations, the fourth is a large flake fragment and the fifth is a large limestone flake. All of them are large (1) and very large artifacts (4), which made them suitable to be exploited as cores. However, none of these artifacts were exploited after the movement. This suggests that perhaps they were picked up as a reserve of raw material in anticipation of a future knapping that never happened.

No bidirectional movement shows a pattern as robust as that pointed out by the unidirectional connections from levels L and M. Although other levels show more complex patterns, they tend to exhibit unidirectional trends. Some connections may suggest bidirectional relationships, but they are normally single movements in a context that remains basically unidirectional. As an example of this, we will present the preliminary results from level P, although the refitting program of this unit has not been finished yet. As can be seen in Figure 13, some areas are at the same time origin and destination of artifact movements, although west to east movements seems to be dominant. Anyway, the refitting pattern form level P will be thoroughly analyzed in future works.

Regardless of whether these bidirectional patterns are confirmed, level P exhibits another interesting singularity with respect to the rest of stratigraphic units of Abric Romaní. This singularity highlights the inter-assemblage variability in terms of the mode of displacement. Transport of cores modified after the movement seems particularly common at the P level (5 of the 15 long-distance displacements documented at this level correspond to this type), but it is less common at all levels (4 cases in level J, one at level L). In this respect, the case of level M is particularly significant, since 7 core movements have been documented in this layer but none of them were modified after. At level P, deferred exploitation of cores was a common strategy. In four of the five core movements, the last reduction stage was carried out in the same area at the middle of the rock-shelter. In one case, the movement of the core coincides with a change in the exploitation strategy (Fig. 14). The core began to be exploited following a centripetal bifacial strategy, concentrating this phase of the production at the extreme west of the site, in squares P-Q60 (Fig. 15). One of the first flakes detached during this stage of the reduction sequence was moved 7 m to the northeast, into square U54. The final moment of the reduction sequence was characterized by a change in the knapping strategy and the production goal. Three elongated blanks were produced following according to a volumetric conception and it seems that the core nucleus was moved at least twice during this stage. The two first elongated flakes were found in squares P57-58, while the last elongated flake and the core were recovered respectively at squares S52 and S53. It will be worth exploring whether this differential feature of level P is somehow related to its main technological singularity, the production of blades and bladelets.

Comparing the Romaní patterns with those identified at other sites is not an easy endeavor. Although we have a relatively large number of assemblages for which lithic refitting data are available, detailed information on connection distances, long-distance refits, direction of movements or characteristics of the moved artifacts are not always provided. In addition, there is not a general agreement on the way of presenting this information. Anyway, it seems that the different scenarios observed throughout the Abric Romaní sequence have been already documented at other Middle Paleolithic assemblages. An extensive review of refitting data from Middle Paleolithic sites is beyond the scope of this paper, but most examples indicate that the occupational contemporaneity between activity areas is generally hard to establish. In some cases, the different knapping spots remain unconnected, like in Wallertheim (Conard and Adler 1997) and Grotte Vaufrey (Geneste 1988). Other sites show long-distance movements and inter-area connections, but unidirectional patterns tend to predominate. This is the case, for instance, at the series N2b/sector 3 from Bettencourt-Saint-Ouen (Locht 2002), Site C of Maastricht-Belvédère (Roebroeks 1988), Villiers-Adam and Beauvais (Locht 2001). Finally, more complex scenarios also appear. In Site K of Maastricht-Belvédère, De Loecker (1994, 2004) has suggested the contemporaneous occupation of different activity areas connected through refits. However, most of the movements described by De Loecker start in a main cluster of artifacts located in the southeastern part of the excavated area, in which the first stages of most reduction sequences were carried out. From this main cluster, several artifacts were moved to other areas, producing a long-distance refitting pattern characterized by a unidirectional trend. This scenario is similar to that described for level M of Abric Romaní, where the central area near the wall was the main knapping area from which artifacts were moved.

It has been suggested that the interrelationship between activity areas would be higher in Upper Paleolithic contexts (Roebroeks 1988), particularly exemplified by some open-air sites traditionally considered as references for archeological campsites. However, dominance of unidirectional patterns is also evident in some of these sites. For example, at the Late Upper Paleolithic site of Rekem, twelve lithic clusters were identified, most of them connected by the movement of lithic artifacts (De Bie 2007). Nevertheless, only two of these clusters are connected by bidirectional movements, while the rest of the inter-cluster connections are unidirectional. The Aurignacian open-air site of Régismont-le-Haut is particularly interesting as comparison with the Abric Romaní, since it also exhibits a discrete distribution pattern in which most of the archeological record is clustered in hearth-related areas (Anderson et al. 2018). One of these hearth-related areas was the centre of activities, showing the highest density of lithic remains. Most of the long-distance connections correspond to artifacts moved from this activity area to other hearth-related zones, producing a refitting pattern in which unidirectional movements are dominant. Even in level IV20 of Pincevent – maybe the best example of occupational contemporaneity between habitation units –, the most common connections correspond to unidirectional movements, although some bidirectional links have been identified (Orliac et al. 2014). In fact, the strongest argument supporting the contemporaneity of most units is based on bone refitting, which suggests that parts of the same carcasses were shared between different hearth-related areas (Enloe and David 1992).

In short, several sites exhibit robust unidirectional patterns and the evidence for bidirectional movements are much less straightforward. The interpretation of these data in terms of temporal dynamics is not an easy task and requires a complex discussion. The unidirectional refit pattern identified in these layers indicates that artifact movement cannot be used to reject our default hypothesis, according to which the activity areas are not contemporaneous. We think therefore that recycling is the most parsimonious explanation for the majority of these displacements. This suggests that during the formation process of archeological assemblages a moment arrive from which the site is considered a suitable location for lithic provisioning. Throughout the formation of stratigraphic units, archeological assemblages are dynamic entities, subject to continuous modification due to natural and anthropogenic causes. In this sense, each event of activity depends on what happened previously, an in turn conditions what will happen later. Knapping events characterized by the reduction of entire nodules and the generation of large clusters of lithic remains create the conditions for recycling and artifact movement. Examples like those from level M, Site K of Maastricht-Belvédère or Régismont-le-Haut point in this direction. Most long-distance movements stem from these large knapping accumulations, whose occurrence should be considered as turning points in the history of assemblage formation. These knapping events probably changed the role of the site in the settlement system and conditioned the behavior of further occupants.

## 5. Conclusions

The lithic refitting from the Middle Paleolithic levels of the Abric Romaní has allowed us to assess different questions related to the intrasite movement of artifacts. This issue has important implications, especially concerning the temporal relations between activity areas and the social and behavioral patterns that can be inferred from them. We have adopted a generalist and quantitative approach to long-distance refits, even if we recognize that, in order to establish the cause of the displacements, each connection has to be analyzed on a case-by-case basis. We should bear in mind that different processes may have contributed to generate the connection patterns. It is even possible that the same artifact has been affected by different processes of movement along the formation of the lithic assemblage. However, we think that refitting studies should try to overcome a casuistic approach in order to promote inter-site comparisons, which are essential for obtaining far-reaching behavioral or evolutionary interpretations.

Contextual data and the characteristics of displacements themselves suggest that natural processes have not played a determinant role on mobility patterns in Abric Romaní, although the incidence of these processes can not be ruled out in some cases. The topography of the level plays sometimes a role in the pattern of long-distance connections, especially as a feature conditioning human movements, as seems to be the case in sublevel Ja. The intrasite movement of artifacts must be considered a factor in the behavioral variability, at two levels:

- The own existence or not of movements. In general, there is a relation between the degree of occupational redundancy and the degree of displacement of artifacts, suggesting that formation length plays an important role in movement patterns.

- The mode of movements, that is, the technological characteristics of the moved artifacts and the actions carried out with them after the movement.

Most displacements occur between hearth-related domestic areas or have a hearth related domestic area as starting point. Few displacements can be interpreted in terms of functional complementarity. However, this is undoubtedly related to the low degree of functional specialization shown by the spatial organization in Abric Romaní. All sorts of artifacts can be moved, but the data indicate a greater mobility of large artifacts, especially cores. The convergence of movements to specific areas of the site allows the existence of provisioning episodes to be identified. In these events, several artifacts were collected in different areas of the site and displaced to the same place. These phenomena reinforce the intentional nature of the movements. Some transport events seem to be associated with the selection of *débordant* flakes, following a selection criterion similar to that observed at the intersite level.

As for the discussion about the contemporaneity of the areas of activity connected by the displacements, we believe that the unidirectional patterns documented at some levels (J, L, M) are more consistent with the hypothesis that these areas are successive in time. We believe that this is the most parsimonious interpretation. In this context, intentional displacements would be related to the recycling of abandoned lithic remains in previous occupational events. The bi-directional movements pointed at some levels correspond to less robust patterns and constitute a weak argument to support that the activity areas were contemporaneous. The comparison between lithic and faunal refits provides additional insights. At some levels, lithic are much more mobile than bones, which suggest that bones and lithics were not affected by the same movement factors. However, this issue should be addressed in the context of a general comparative analysis of the connections between areas of activity documented in the Middle Paleolithic. Anyway, we recognize the uncertainties surrounding these interpretations. Alternative hypotheses could be proposed that would be difficult to refute. Therefore, maybe it would be a good idea to direct the spatial analysis towards issues more adjusted to the nature of the record we are working with, beyond the ethnographic paradigm.

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**References**

Anderson L, Lejay M, Brugal JP, Costamagno S, Heckel C, de Araujo Igreja M, Pradeau JV, Salomon H, Sellami F, Théry-Parisot I, Barshay-Szmidt C, Mensan R, Bon F (2018) Insights into Aurignacian daily life and camp organization: The open-air site of Régismont-le-Haut. Quaternary International, doi: 10.1016/j.quaint.2018.04.034.

Bailey G (2007) Time perspectives, palimpsests and the archaeology of time. Journal of Anthropological Archaeology 26:198-223.

Bailey G, Galadinou N (2009) Caves, palimpsests and dwelling spaces: examples from the Upper Palaeolithic of south-east Europe. World Archaeology 41:215-241.

Balek CL (2002) Buried artifacts in stable upland sites and the role of bioturbation: A review. Geoarchaeology 17:41-51.

Bargalló A, Gabucio MJ, Rivals F (2016) Puzzling out a palimpsest: Testing an interdisciplinary study in level O of Abric Romaní. Quaternary International 417:51-65.

Barkai R, Lemorini C, Vaquero M (2015) The origins of recycling: A Paleolithic perspective. Quaternary International 361:1-3.

Barton RNE, Bergman CA (1982) Hunters at Hengistbury: some evidence from experimental archaeology. World Archaeology 14:237-248.

Bertran P, Beauval C, Boulogne S, Brenet M, Costamagno S, Feuillet T, Laroulandie V, Lenoble A, Malaurent Ph, Mallye J-B (2015) Experimental archaeology in a mid-latitude periglacial context: insight into site formation and taphonomic processes. J Archaeol Sci 57:283–301.

Binford LR (1978) Dimensional analysis of behavior and site structure: learning from an Eskimo hunting stand. American Antiquity 43(3):330-361.

Binford LR (1981) Behavioral archaeology and the “Pompeii premise”. Journal of Anthropological Research 37:195-208

Binford LR, Mills MGL, Stone NM (1988) Hyena scavenging behaviour and its implications for interpretation of faunal assemblages from FLK22 (the Zinj Floor) at Olduvai Gorge. J. Anthropol Archaeol 7:99-135.

Böeda E, Pelegrin J (1985) Approche expérimentale des amas de Marsagny. Archéologie Expérimentale 1:19-36.

Cáceres I, Bennàsar M, Huguet R, Rosell J, Saladié P, Allué E, Solé A, Blasco R, Campeny G, Esteban-Nadal M, Fernández-Laso C, Gabucio MJ, Ibáñez N, Martín P, Muñoz L, Rodríguez-Hidalgo A (2012) Taphonomy of Level J of Abric Romaní. In: Carbonell E (ed) High Resolution Archaeology and Neanderthal Behavior. Time and Space in Level J of Abric Romaní (Capellades, Spain). Springer, Dordrecht, pp. 159-185.

Camarós E, Cueto M, Teira LC, Tapia J, Cubas M, Blasco R, Rosell J, Rivals F (2013) Large carnivores as taphonomic agents of space modification: an experimental approach with archaeological implications. J Archaeol Sci 40(2):1361–1368.

Chacón Navarro MG, Fernández-Laso MC, Rivals F (2014) Comportements des populations néandertaliennes pendant le MIS 3 à l’Abric Romaní : les niveaux K, L et M. Variabilité ou continuité ? In : Jaubert J, Fourment N, Depaepe P (eds.) Transitions, ruptures et continuité en Préhistoire. Actes du XXVIIe congrès préhistorique de France. Vol. 2. Paléolithique et Mésolithique. Société Préhistorique Française, Paris, pp. 207-228.

Clark AE (2017) From Activity Areas to Occupational Histories: New Methods to Document the Formation of Spatial Structure in Hunter-Gatherer Sites. Journal of Archaeological Method and Theory 24(4):1300-1325.

Conard NJ, Adler DS (1997) Lithic Reduction and Hominid Behavior in the Middle Paleolithic of the Rhineland. Journal of Anthropological Research 53:147-175.

Cziesla E (1990) On refitting of stone artifacts. In: Cziesla E, Eickhoff S, Arts N, Winter D (eds.) The Big Puzzle. International Symposium on Refitting Stone Artefacts. Monrepos 1987. Studies in Modern Archaeology 1. Holos, Bonn, pp. 9-44.

De Bie M (2007) Benefiting from Refitting in Intra-Site Analysis: Lessons from Rekem (Belgium). In: Schurmans U, De Bie M (eds.) Fitting Rocks: Lithic Refitting Examined. BAR International Series 1596. Archaeopress, Oxford, pp. 31-44.

De Loecker D (1994) On the reffiting analysis of Site K: a Middle Palaeolithic findspot at Maastricht-Belvédère (The Netherlands). Ethnographisch-Archëologische Zeitschrift 35:107-117.

De Loecker D (2004) Beyond the Site: the Saalian Archaeological Record at Maastricht-Belvédère (The Netherlands). Analecta Praehistorica Leidensia 35/36. University of Leiden, Leiden.

Enloe JG (2003) Food sharing past and present: archaeological evidence for economic and social interactions. Before Farming 1(1):1-23.

Enloe JG, David F (1992). Food sharing in the Paleolithic: carcass refitting at Pincevent. In: Hofman JL, Enloe JG (eds) Piecing Together the Past: Applications of Refitting Studies in Archaeology. BAR International Series 578, Oxford, pp. 296-315.

Gabucio MJ, Cáceres I, Rivals F, Bargalló A, Rosell J, Saladié P, Vallverdú J, Vaquero M, Carbonell E (2018) Unraveling a Neanderthal palimpsest from a zooarcheological and taphonomic perspective. Archaeological and Anthropological Science 10:197-222.

Geneste JM (1988) Les industries de la Grotte Vaufrey: technologie du débitage, économie et circulation de la matière première lithique. In: Rigaud JP (ed) La Grotte Vaufrey à Cenac et Saint-Julien : paleoenvironnements, chronologie et activités humaines. Société Préhistorique Française, Paris, pp. 441-517.

Kvamme KL (1997) Patterns and models of debitage dispersal in percussion flaking. Lithic Technology 22(2), 122-138.

Locht JL (2001) Modalités d'implantation et fonctionnement interne des sites. L'apport de trois gisements de plein air de la phase récente du Paléolithique moyen dans le nord de la France (Bettencourt-Saint-Ouen, Villiers-Adam et Beauvais). In : Conard NJ (ed) Settlement Dynamics of the Middle Paleolithic and Middle Stone Age. Kerns Verlag, Tübingen, pp. 361-393.

Locht JL (2002) Bettencourt-Saint-Ouen (Somme). Cinq occupations paléolithiques au début de la dernière glaciation. Éditions de la Maison des Sciences de l’Homme, Paris.

Lyman RL (2003) The influence of time averaging and space averaging on the application of foraging theory in zooarchaeology. Journal of Archaeological Science 30:596-610.

Malinsky-Buller A, Hovers E, Marder O (2011) Making time: ‘Living floors’, ‘palimpsests’ and site formation processes – A perspective from the open-air Lower Paleolithic site of Revadim Quarry, Israel. Journal of Anthropological Archaeology 30(2): 89-101.

Modolo M, Rosell J (2016) Reconstructing occupational models: Bone refits in Level I of Abric Romaní. Quaternary International 435(A): 180-194.

Morrow TM (1996) Lithic Refitting and Archaeological Site Formation Processes. A Case Study from the Twin Dicht Site, Greene County, Illinois. In: Odell GH (ed.) Stone Tools: Theoretical Insights into Human Prehistory. Plenum Press, New York, pp. 345-373.

Newcomer MH, Sieveking G de G (1980) Experimental flake scatter-patterns: a new interpretative technique. Journal of Field Archaeology 7:345-352.

O'Brien M (2015) Evaluating the Contemporaneity of Households at the Eden-Farson site. International Journal of Osteoarchaeology 25(5):653-664.

O’Connell JF (1987) Alyawara site structure and its archaeological implications. American Antiquity 52(1):74-108.

O'Connell JF, Hawkes K, Blurton Jones N (1991) Distribution of Refuse-Producing Activities at Hadza Residential Base Camps. Implications for Analyses of Archaeological Site Structure. In: Kroll EM, Price TD (eds.) The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York, pp. 61-76.

Olive M, Morgenstern M (2004) L’organisation de l’espace habité. In: Pigeot N (ed.) Les derniers magdaléniens d’Étiolles. Perspectives culturelles et paléohistoriques (l’unité d’habitation Q31). XXXVII$^{e}$ supplément à Gallia Préhistoire. CNRS Editions, Paris, pp. 181-220.

Orliac M, Julien M, Bodu P, Enloe JG (2014) Mise en évidence d’un campement. In: Julien M, Karlin C (eds.) Un automne à Pincevent. Le campement magdalénien du niveau IV20. Mémoire 57. Société préhistorique française, Paris, pp. 63-69.

Petraglia MD (1992) Stone artifact refitting and formation processes at the Abri Dufaure, an Upper Paleolithic site in Southwest France. In: Hofman JL, Enloe JG (eds) Piecing Together the Past: Applications of Refitting Studies in Archaeology. BAR International Series 578, Oxford, pp. 163-178.

Rapson DJ, Todd LC (1992) Conjoins, Contemporaneity, and Site Structure: Distributional Analyses of the Burgas-Holding Site. In: Hofman JL, Enloe JG (eds.) Piecing Together the Past: Applications of Refitting Studies in Archaeology. BAR International Series 578. Archaeopress, Oxford, pp. 238-263.

Rick JW (1976) Downslope movement and archaeological intrasite spatial analysis. Am Antiq 41(2):133-144.

Rick TC (2002) Eolian processes, ground cover, and the archaeology of coastal dunes: A taphonomic case study from San Miguel Island, California, U.S.A. Geoarchaeology 17:811-833.

Roebroeks W (1988) From find scatters to early hominid behaviour. A study of Middle Palaeolithic riverside settlements at Maastricht-Belvédère (The Netherlands). Analecta Praehistorica Leidensia 21. University of Leiden, Leiden.

Rosell J, Blasco R, Fernández-Laso MC, Vaquero M, Carbonell E (2012a) Connecting areas: Faunal refits as a diagnostic element to identify synchronicity in the Abric Romaní archaeological assemblages. Quaternary International 252:56-67.

Rosell J, Blasco R, Huguet R, Cáceres I, Saladié P, Rivals F, Bennàsar M, Bravo P, Campeny G, Esteban-Nadal M, Fernández-Laso C, Gabucio MJ, Ibáñez N, Martín P, Muñoz L, Rodríguez-Hidalgo A (2012b) Occupational Patterns and Subsistence Strategies in Level J of Abric Romaní. In: Carbonell E (ed) High Resolution Archaeology and Neanderthal Behavior. Time and Space in Level J of Abric Romaní (Capellades, Spain). Springer, Dordrecht, pp. 313-372.

Schick KD (1986) Stone Age Sites in the Making: Experiments in the Formation and Transformation of Archaeological Occurrences. BAR International Series 319, Oxford.

Schiffer MB (1985) Is there a “Pompeii premise” in archaeology? Journal of Anthropological Archaeology 41: 18-41.

Schurmans UA (2007) Refitting in the Old and New Worlds. In: Schurmans U, De Bie M (eds.) Fitting Rocks: Lithic Refitting Examined. BAR International Series 1596. Archaeopress, Oxford, pp. 7-23.

Sharp WD, Mertz-Kraus R, Vallverdú J, Vaquero M, Burjachs F, Carbonell E, Bischoff, JL (2016) Archeological deposits at Abric Romaní extend to 110 ka: U-series dating of a newly cored, 30 meter-thick section. Journal of Archaeological Science Reports 5:400–406.

Stevenson MG (1991) Beyond the Formation of Hearth-Associated Artifact Assemblages. In: Kroll EM, Price TD (eds) The Interpretation of Archaeological Spatial Patterning. Plenum Press, New York, pp. 269-299.

Sullivan III AP (2008) Time Perspectivism and the Interpretive Potential of Palimpsests: Theoretical and Methodological Considerations of Assemblage Formation History and Contemporaneity. In: Holdaway S, Wandsnider L (eds) Time in Archaeology: Time Perspectivism Revisited. The University of Utah Press, Salt Lake City, pp. 31-45.

Theunissen R, Balme J, Beck W (1998). Headroom and human trampling: cave ceiling-height determines the spatial patterning of stone artefacts at Petzkes Cave, northern New South Wales. Antiquity 72:80-9.

Todd LC, Stanford DJ (1992) Application of conjoined bone data to site structural studies. In: Hofman JL, Enloe JG (eds) Piecing Together the Past: Applications of Refitting Studies in Archaeology. BAR International Series 578, Oxford, pp 21-35.

Vallin L, Masson B, Caspar JP (2001) Taphonomy at Hermies, France: A Mousterian Knapping Site in a Loessic Context. Journal of Field Archaeology 28(3-4):419-436.

Vallverdú J, Allué E, Bischoff JL, Cáceres I, Carbonell E, Cebrià A, García-Antón D, Huguet R, Ibáñez N, Martínez K, Pastó I, Rosell J, Saladié P, Vaquero M (2005) Short human occupations in the Middle Palaeolithic level i of the Abric Romaní rock-shelter (Capellades, Barcelona, Spain). Journal of Human Evolution 48(2):157-174.

Vallverdú-Poch J (2018) Investigación geoarqueológica en los depósitos de ocupación musterienses del Pleistoceno superior del Abric Romaní (Capellades, Barcelona, España). Boletín Geológico y Minero 129(1/2):129-152.

Vallverdú-Poch J, Gómez de Soler B, Vaquero M, Bischoff JL (2012) The Abric Romaní Site and the Capellades Region. In: Carbonell E (ed.) High Resolution Archaeology and Neanderthal Behavior. Time and Space in Level J of Abric Romaní (Capellades, Spain). Springer, Dordrecht, pp. 19-46.

Vaquero M (1999) Intrasite spatial organization of lithic production in the Middle Palaeolithic: the evidence of the Abric Romaní (Capellades, Spain). Antiq 73:493-504.

Vaquero M (2008) The history of stones: behavioural inferences and temporal resolution of an archaeological assemblage from the Middle Palaeolithic. Journal of Archaeological Science 35:3178-3185.

Vaquero M (2011) New perspectives on recycling of lithic resources using refitting and spatial data. Quartär 58:113-130.

Vaquero M, Allué E, Bischoff JL, Burjachs F, Vallverdú J (2013) Environmental, depositional and cultural changes in the Upper Pleistocene and Early Holocene: the *Cinglera del Capelló* sequence (Capellades, Spain). Quaternaire 24(1):49-64.

Vaquero M, Bargalló A, Chacón MG, Romagnoli F, Sañudo P (2015) Lithic recycling in a Middle Paleolithic expedient context: Evidence from the Abric Romaní (Capellades, Spain). Quaternary International 361:212–228.

Vaquero M, Chacón G, Fernández C, Martínez K, Rando JM (2001) Intrasite Spatial Patterning and Transport in the Abric Romaní Middle Paleolithic Site (Capellades, Barcelona, Spain). Conard NJ (ed) Settlement Dynamics of the Middle Paleolithic and Middle Stone Age. Kerns Verlag, Tübingen, pp. 573-595.

Vaquero M, Chacón MG, García-Antón MD, Gómez de Soler B, Martínez K, Cuartero F (2012a) Time and space in the formation of lithic assemblages: The example of Abric Romaní Level J. Quaternary International 247:162-181.

Vaquero M, Chacón MG, Cuartero F, García-Antón MD, Gómez de Soler B, Martínez K (2012b) The Lithic Assemblage of Level J. In: Carbonell E (ed.) High Resolution Archaeology and Neanderthal Behavior. Time and Space in Level J of Abric Romaní (Capellades, Spain). Springer, Dordrecht, pp. 189-311.

Vaquero M, Chacón MG, Rando JM (2007) The interpretive potential of lithic refits in a Middle Paleolithic site: Abric Romaní (Capellades, Spain). In: Schurmans U, De Bie M (eds) Fitting Rocks. Lithic Refitting Examined. BAR International Series 1596, Oxford, pp. 75-89.

Vaquero M, Fernández-Laso MC, Chacón MG, Romagnoli F, Rosell J, Sañudo P (2017) Moving things: Comparing lithic and bone refits from a Middle Paleolithic site. Journal of Anthropological Archaeology 48:262-280.

Villa P (1982) Conjoinable Pieces and Site Formation Processes. Am Antiq 47(2):276-290.

**Figure captions**

Figure 1. a, b. Geographic location of Abric Romaní in Northeastern Iberia; c. synthetic lithostratigraphic column; d, e. images of Abric Romaní during the excavation of level M. Legend for the lithological column: 1. red sands; 2. carbonatic sands; 3. filiform travertines; 4. tubular travertines; 5. carbonatic slabs; 6. oncolithic gravels; 7. travertine blocks.

Figure 2. Transversal (A) and longitudinal (B) vertical projections of the lithic artifacts recovered at the archeological levels discussed in the text.

Figure 3. Scatter plots of the Abric Romaní units discussed in the paper: A) number of artifacts against mean connection length, B) number of artifacts against frequency of long-distance refits, and C) number of artifacts against frequency of long-distance refits after excluding level L.

Figure 4. Map of sublevel Ja indicating the direction of the long-distance movements. The origin and destination of the connections are marked respectively by blue and red dots.

Figure 5. Map of level K indicating the distribution of lithic artifacts and the two long-distance movements identified in this layer.

Figure 6. Map of level L indicating the distribution of lithic artifacts and the long-distance movements identified in this layer.

Figure 7. Moved artifacts from level L.

Figure 8. Map of level M indicating the the main lithic accumulations identified in this layer.

Figure 9. Map of level M indicating the the two long-distance movements identified in this layer.

Figure 10. Artifacts moved to accumulation M1 of level M.

Figure 11. Artifacts moved to square N54 of level M.

Figure 12. Four of the five artifacts moved to squares K52-53 and L52-53 of level M.

Figure 13. Map of level P indicating the direction of the long-distance movements. The origin and destination of the connections are marked respectively by blue and red dots.

Figure 14. Refitting of the RMU Chert-009. Above, first stage of the reduction sequence, aimed at the production of flakes according to a bifacial centripetal strategy. Below, final stage of the reduction sequence, aimed at the production of elongated flakes according to a volumetric conception.

Figure 15. Map of level P showing the distribution of the lithic artifacts corresponding to the RMU Chert-009. Arrows indicate the movements inferred from refitting.